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RESEARCH ARTICLE

THE MAGNETIC INFLUENCE OF TATTOOS IN MRI SCANS

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Abstract

This paper talks about how tattoos can heat up during an MRI scan at 1.5 T and 3 T field strengths. The researchers looked at different types of tattoos with varying shapes, positions, pigments, sizes, and the gaps between them. They used special simulations to measure how much energy (SAR) is absorbed and how much the temperature rises around the tattoos. The study found that tattoos can affect how the electric field from the MRI spreads out and how much energy is absorbed by the skin. The heating was more noticeable around sharp edges, long strips, and circular shapes of tattoos. The shape of the tattoo was a key factor in how much the skin temperature would rise. The position and size of tattoos also played a role in the heating. The researchers also looked at what happens when someone has multiple tattoos. The results showed that RF heating from multiple tattoos is very different from a single tattoo. It doesn't just add up like you might expect from each tattoo's individual effect.

Introduction: -

The foundation for MRI was laid in the 1940s with the discovery of nuclear magnetic resonance (NMR) by Felix Bloch and Edward Purcell, for which they won the Nobel Prize in 1952. The first MRI scanner was developed in the 1970s, with significant contributions from Paul Lauterbur, who discovered how to create images using NMR, and Raymond Damadian, who proposed using MRI for medical diagnoses. In 1977, the first human MRI scan was conducted. Since then, MRI technology has advanced rapidly, with high-resolution imaging and functional MRI (fMRI) allowing for studies of brain activity. Today, MRI is a key tool in diagnosing a wide range of medical conditions.Tattooing is a global trend, and while it has become increasingly popular, clinical knowledge of complications associated with tattoos is largely based on case reports collected over the years. However, larger cohorts reflecting complications related to contemporary tattoo trends are still lacking. Magnetic Resonance Imaging (MRI) is one of the most advanced and non-invasive imaging techniques in modern medicine. It provides highly detailed images of the internal structures of the body, helping doctors diagnose a wide range of conditions, from neurological disorders to musculoskeletal injuries. Unlike X-rays or CT scans, MRI does not use ionizing radiation, making it a preferred option for many diagnostic procedures.With the rising popularity of tattoos, many individuals

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are concerned about how the ink on their skin might interact with MRI technology. Tattoos, created by inserting ink into the dermal layer of the skin, often contain metals such as iron oxide, titanium, and copper. This raises concerns about whether these metals might interfere with MRI's powerful magnetic fields, potentially affecting image quality or causing discomfort during the procedure.This article will explore the potential effects of tattoos on MRI scans, how tattoos may influence the procedure, and what precautions can be taken to ensure a safe and accurate imaging experience for tattooed individuals. By understanding the relationship between tattoos and MRI, we hope to provide clarity for those concerned about how their tattoos may affect their diagnostic experience.

The Science Behind MRI: How Magnetic Resonance Imaging Works: -

MRI works on the principle of nuclear magnetic resonance (NMR), which involves aligning hydrogen nuclei (protons) in the body using a strong magnetic field. When a patient enters the MRI scanner, the magnetic field causes the protons in the body's tissues, particularly those in water molecules, to align in a specific direction. A radiofrequency pulse is then applied, temporarily knocking these protons out of alignment. As the protons return to their original alignment, they emit energy in the form of signals, which are detected by the MRI machine. These signals differ based on the type of tissue—muscles, fat, organs—since each tissue type interacts with the magnetic field differently.

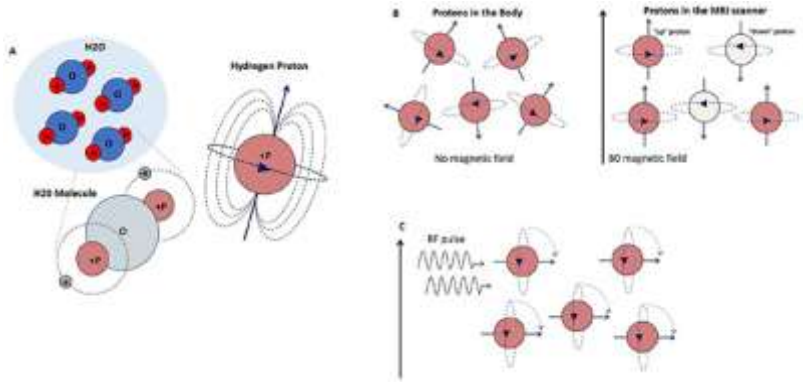

Fig 1. Magnetic effects on Atoms

The Impact of Tattoos on MRI Scans: -

Tattoos are created by inserting ink into the dermis, the layer beneath the skin's outermost layer (epidermis). The ink used in tattoos often contains various pigments, some of which may include metallic compounds such as iron oxide, titanium dioxide, or copper

Fig 2.MRI Scanning process

The presence of these metals raises concerns about how they might interact with the strong magnetic fields used in MRI scans. While the magnetic fields in MRIs could potentially cause the metallic components of the ink to heat up, leading to discomfort or a warming sensation, such reactions are rare and typically not severe. Some individuals may feel slight warmth or a mild burning sensation around the tattoo during the MRI, but such reactions are usually harmless and tend to subside quickly.Although most people with tattoos do not face significant issues during an MRI, there is still a possibility of minor discomfort or slight distortion in the images, especially if the tattoo is large or contains a higher concentration of metallic pigments.

Types of Tattoo Inks and Their Magnetic Properties: -

Tattoo inks can be broadly classified into two categories based on their magnetic properties: metallic and non-metallic inks. Understanding the composition of these inks is crucial when assessing potential MRI-related risks.

Metallic Inks often contain ferromagnetic materials such as iron oxide, titanium dioxide, and chromium, which are highly susceptible to magnetic fields. When exposed to the strong magnetic fields in an MRI, these metallic pigments can heat up significantly, leading to potential risks such as skin irritation, swelling, or even burns at the tattoo site. Tattoos with a high concentration of metallic pigments, particularly iron oxide, are more likely to cause these reactions due to the strong magnetic pull exerted by the MRI's field. This is a significant concern, as the heat generated can cause discomfort or damage to the skin. On the other hand, Non-Metallic Inks primarily consist of carbon-based pigments, which are generally considered safer for MRI scans. These inks do not interact significantly with the magnetic fields used in MRI technology, making them less likely to cause heating or discomfort. As a

result, non-metallic tattoos pose minimal risk during MRI procedures and are often considered the safer option when compared to metallic inks.

Fig.3 Different types of tattoos design

Risks and Concerns of Tattoos During MRI: -

While MRI is generally safe for tattooed individuals, there are some risks associated with the procedure.

The most common concerns include:

- **Skin Irritation**: In rare cases, the heat generated by the MRI's magnetic field may cause irritation, redness, or swelling at the site of the tattoo.
- **Image Distortion**: The metallic pigments in tattoos can potentially cause distortion or artifacts in MRI images, though this is generally minimal and only happens in certain areas of the body.
- **Burning Sensations**: Some patients report a sensation of warmth or even a mild burning feeling at the tattooed area during the MRI scan, particularly if the tattoo contains metallic pigments like iron oxide.

Discussion: -

In simple terms, patients with cosmetic tattoos can still undergo an MRI scan, even though there is a very small chance that the tattoo could cause a mild skin reaction, usually in the form of a minor burn. However, it is important to identify tattoos that are more likely to cause issues, such as those with black ink or pigments containing iron oxide. Tattoos with certain designs, like loops, large circles, or multiple adjacent points, are also considered "at risk."For these patients, a cold compress can be used beforehand to prevent discomfort during the MRI. Alternatively, if the patient experiences irritation from an electrical arc between two tattoos, a towel or cloth can be placed between the tattooed areas to reduce the reaction and help complete the MRI safely.

Real-World Case: The Impact of Tattoos on MRI:-

The first documented case of an MRI-induced reaction due to a tattoo was reported by Kredstein et al. in 1997. In this case, the patient experienced sudden burning pain in the area of an abdominal tattoo when exposed to the static magnetic field as she entered the MRI suite. As a result, the tattooed skin had to be surgically removed and the site closed up to allow the MRI to be completed. The authors further investigated the magnetic properties of the tattoo pigments and found that the iron oxide-based pigments, which are commonly used in black and brown tattoos, reacted to the magnetic field by moving toward a standard horseshoe magnet. However, other pigments like those based on carbon, titanium, and copper showed no reaction to the magnetic field. The potential effects of tattoos on MRI scans are not just theoretical; real-world cases have brought attention to this issue, particularly in athletes. One such case involves a professional football player who experienced an immediate and sustained cutaneous reaction, often referred to as a "burn," at the site of lower extremity tattoos during an MRI of the pelvis. This reaction was attributed to an electromagnetic response caused by ferromagnetic metallic compounds, especially iron oxide, in the tattoo pigments (Ross JR et.al ,2012) These metallic compounds can interact with the strong magnetic fields of an

MRI, creating an electric current that increases local skin temperature, potentially leading to a burn. Tattoos that are "at risk" typically include those with black pigment or any other pigments containing iron oxide, as well as designs featuring loops, large circular objects, or multiple adjacent points. This case emphasizes the importance of recognizing the possible discomfort or skin irritation that tattoos could cause during an MRI scan, particularly in athletes, whose tattoos are often large and intricate. While reactions like these are rare and typically do not lead to long-term damage, they may cause temporary discomfort during the scan. In the case of the football player, the burn was addressed with a cold compress, allowing for the completion of the MRI. This incident serves as an underreported issue that warrants attention in sports medicine literature, especially given the prevalence of tattoos among athletes who frequently require MRI scans for musculoskeletal injuries. Importantly, no permanent sequelae were noted, and patients experiencing this reaction can be reassured that it is typically short-lived.

In response to this case, Kanal and Shellock recommended a precautionary approach for patients with tattoos. They suggested that doctors apply an ice pack or cold compress to the tattoo before the MRI, leaving it in place until the procedure is completed. They also recommended using a pressure dressing to prevent any distortion or damage to the tissue. These conservative measures should be tried before resorting to more invasive procedures, such as surgically removing the tattooed skin.

How to Prepare for an MRI with Tattoos: -

If you have tattoos and are scheduled for an MRI, there are a few steps you can take to ensure the procedure goes smoothly:

- **Inform the Technician**: Always inform the MRI technician about your tattoos before the scan. This allows them to take any necessary precautions and adjust the scan if needed.

- **Avoid Tattooed Areas**: If possible, the technician may try to avoid scanning directly over heavily tattooed areas, particularly if the tattoo is large or if there are concerns about potential interactions with the MRI.
- **Use Cooling Creams**: In some cases, your healthcare provider may recommend using cooling creams or gels to reduce any discomfort during the procedure.

- **Consider Ink Type**: If you are planning to get a tattoo and are concerned about future MRI scans, consider discussing the type of ink used with the tattoo artist. While most tattoos do not cause issues, non-metallic inks may reduce the likelihood of complications.

Potential Long-Term Effects of MRI on Tattoos:-

While most reactions to MRI scans involving tattoos are temporary and resolve quickly, there is limited research on whether there could be long-term effects, especially for those with multiple tattoos or large areas of the body covered in ink. Some might wonder whether repeated exposure to MRI scans could lead to skin damage, tattoo fading, or other dermatological concerns.Although there has been no conclusive evidence suggesting permanent harm, it is important to explore these considerations and provide advice on how individuals with tattoos can protect their skin and the quality of their tattoos. For example, ensuring that tattoos are fully healed before an MRI and discussing any concerns with healthcare providers beforehand can be helpful.

Conclusion:-

The main point of this study is that MRI machine’s radio frequency (RF) waves can cause heating around tattoos, and the level of heating varies depending on the tattoo’s type, size, shape, and position. The study found that the position and shape of tattoos are the most significant factors affecting RF-induced heating.If tattoos are larger in size or if there are multiple tattoos, the RF heating can increase. The thickness of tattoos has a smaller effect, but some variation in heating is still observed. Tattoos containing ferromagnetic materials, like iron oxide, are particularly problematic because they react with MRI's radio waves, leading to greater heating. The study highlights that tattoos can potentially lead to overheating during MRI scans, with the most influence coming from their shape, position, and size. Tattoos containing materials that interact with magnetic fields are of particular concern. It’s crucial for healthcare providers to consider these factors when recommending MRIs to tattooed individuals, and further research is needed to ensure safety and minimize risks.

References: -

1. Ross JR, Matava MJ. Tattoo-induced skin "burn" during magnetic resonance imaging in a professional football player: a case report. Sports Health. 2011 Sep;3(5):431-4. doi: 10.1177/1941738111411698. PMID: 23016039; PMCID: PMC3445217.
2. Jackson JG, Acker JD. Permanent eyeliner and MR imaging. AJR Am J Roentgenol. 1987; 149:1080
3. Kreidstein ML, GiguereD, Freiberg A. MRI interaction with tattoo pigments: case report, pathophysiology, and management. PlastReconstr Surg. 1997; 99:1717-1720.
4. Nakamura T, Fukuda K, Hayakawa K, et al. Mechanism of burn injury during magnetic resonance imaging (MRI): simple loops can induce heat injury. Front Med Biol Eng. 2001; 11:117-129
5. Tope WD, Shellock FG. Magnetic resonance imaging and permanent cosmetics (tattoos): survey of complications and adverse events. J MagnReson Imaging. 2002; 15:180-184